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ELECTRICITY AS A SUBJECT FOR STUDY IN ELEMENTARY SCHOOLS

PART I

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For intense and dramatic interest, there is nothing in the realm of forces which equals that inspired by electricity. To the boy in particular, it opens a fairyland into which he needs only an introduction to be charmed and made a willing captive.

In this age of Titanic achievement in the mechanical world, when space and time are being annihilated, when there is such wonderful progress in the manipulation of raw materials, when almost in a flash nature's stores are transformed into articles of service to man, when the realms that have hitherto been unexplored are suddenly transformed into regions of light for man's searching eye to probe, when the infinite oceans of air are pierced and made to vibrate in harmony with man's intelligence, one turns breathless and bewildered with awe to that mysteriously silent and mighty force, electricity, more wonderful in reality than the Genii of the Arabian Nights in story. Were Aladdin brought to life in the twentieth century he would find that man had found an easier way to realize one's wishes than by the process of rubbing a lamp. Now he merely presses a button, or turns a lever and presto! the Genius of Electricity, flashing, silent, and mighty, is at his command, ready to leap through space in defiance of time, or to unite with the might of Thor's hammer. But, wonderful as this is, the first few letters of the alphabet only have been deciphered in the story of this mighty force.

Electricity appeals to the imagination. All of the race experience with fire, that gift of the gods which has done so much to establish man highest in the animal kingdom, is suggested by it, and all the mysticism of the flame which subconsciously we feel when near the glow of a campfire, or by the grate, exerts a subtle influence when one is near the sparkling and crackling flame of electricity.

Space and time, the two great obstacles to free communication, have been comparatively conquered by this rival of fire, and little by little it is bringing the world together into one vast social consciousness. Interest is always intense concerning things of promise, the potential, with which the imagination ever busies itself. So it is not only because of man's past conquests in the field of electricity but also the promise of still greater achievements that accounts for interest in this subject.

Almost everyone has noticed the natural interest which many boys, city boys especially, have in electricity. It is often a dominant spontaneous interest at some time between the ages of ten and fourteen. Contact on all sides with the electrical world undoubtedly induces this interest.

As an evidence of this witness this paper which was written last year by a seventh-grade boy in the University Elementary School:

MY SHOP

I began working with electricity and mechanics when I was about eight years old. The way I got interested in this was through a boy friend of mine whose father was an electrician. I used to go to his home and watch him, and soon I got a little shop myself. I had a few batteries, a bell, and some wire, and I made push-buttons and switches out of tin. I got some sal ammoniac and made little batteries of carbon and zinc in jelly glasses. Soon my father had our barn made into a garage, and when he did this he had a room fitted up for me on the second floor, and I moved my shop from the basement of our house to this room. I got some tools and a lot of old iron and wheels and a lot of other things and put some of these things in the shape of telegraphs, little bells, and motors, but I couldn't get a motor that would run for quite a while. Soon I got a small lathe and emery wheel, and drill-press attachment? Soon after this I got interested in chemistry and put a chemical outfit in my shop and I am there now most all the time.

A little while ago I made an electric furnace which gives a lot of heat. I use this in chemistry for making metals.

A little after this I got a motor to run my lathe and I am making a pump to run by it to get air to run a blast-lamp with.

EDWARD ANDREWS

If for no other reasons than these, (1) the part which electricity plays in our civilization, a part which it is destined to play to a still greater degree; (2) the interest which children feel for it in itself; (3) the interest which the child ought to feel in one of the greatest of nature's controllable forces, these are good and sufficient reasons for giving electricity an important place in the elementary school. Certainly if one of the chief aims of education is to fit one to utilize nature and nature's forces, this cannot be done unless the school gives the child the largest possible contact with natural forces.

HISTORICAL SKETCH

Before proceeding to a consideration of the subject-matter of electricity, suitable for the elementary schools, let us first make a survey of the field in the light of historical development.

Frictional electricity has been known at least for a period of twenty-five hundred years. The Greeks knew of it through rubbing amber. Aside from this nothing further was learned until about 1600 A. D., when Dr. Gilbert, Queen Elizabeth's court physician, after much experimenting, found a considerable list of substances which like amber and jet, when electrified by friction, caused attraction. The Greek name for amber is electron and the phenomenon produced in these substances being the same as in the case of amber, he named it electrification; so it is to Gilbert electricity owes its name. He is called the father of electricity and magnetism.

The first electrical machine was a ball of brimstone mounted on an axis. When turned rapidly, if silk were held firmly against the revolving brimstone, frictional electricity was produced—barely enough to cause a spark. We owe this invention to Otto von Guericke, the burgomaster of Magdeburg, who lived about the middle of the sixteenth century. Experiments with this machine led up to an accidental discovery resulting in the invention of the Leyden jar in its original form in 1745 by Dean von Kleist. With the numerous experiments made possible by the Leyden jar and the friction machine, interest in electricity advanced by leaps and bounds. For the first time in history man could produce and control electricity of a high power. However, he was still dealing with frictional electricity. Then followed a period of play. The learned physicists and scientists of Europe entertained the courts with their wonderful toy and for a half-century it was the plaything of royalty.

A century later America entered the lists for scientific honors with Franklin as her champion. His interesting experiments soon awakened wonderful enthusiasm. In 1752, when he proved by his celebrated kite experiment that electricity and magnetism are identical, he found by his invention of the lightning rod the first means by which a knowledge of electricity could be made of actual service to man. His theories as to electricity were at first given scant recognition by the English experimenters. The French immediately accepted his theories and proved them by experiment which in large part explains Franklin's wonderful popularity with the French during Revolutionary times.

So far scientists were handicapped as the frictional electricity of the static machine stored up in the Leyden jars gave only an instantaneous spark to be experimented with. As yet no one could produce a steady flow or current of electricity.

In 1800 the invention by Volta, of the voltaic pile and later the voltaic cell, made possible a steady flow of electricity by chemical means and scientists were in a position now to study the electric current. Since then events have followed so rapidly that it is difficult for the layman merely to keep pace with them. The science and art of electricity now demands an army of experts, no one of whom can cover the whole field successfully. In 1802 Humphrey Davy produced the electric flame or arc caused by the flow of the current through the juncture of two carbon tips; in 1820 Oersted found that a magnetic needle was deflected if placed near a current. This suggested investigation of the relation between electricity and magnetism or electro-magnetism; in 1822 Faraday produced the first electric motor; in 1825 Sturgeon invented the soft iron electro-magnet, an instrument for using the temporary magnetization produced by the flow of a current of electricity.

This invention marked an epoch. The possibilities were seen to be tremendous. Since then millions of electro-magnets have been made. The electro-magnet is the essential part of the telegraph, the telephone, the sub-marine cable, the relay, the recorder, the motor, the electric signal, the electric bell, and numerous simple electrical machines.

Since the flow of electricity produced a magnetic field, Faraday in 1831 began a series of experiments with magnetism to see if it could be made to produce electricity. His researches resulted in success. His magnet led up to the dynamo which produces electricity by mechanical means. However, until about 1878, electricity had very little commercial or industrial value, aside from its use in the arc light, and in the telegraph which came into use about 1840. The telegraph has been a great aid in the development of rapid railroad transportation. The invention of the dynamo, however, made it possible to transform the energy of water power and heat into the energy of electricity at a much cheaper price than ever before and at enormous pressures. The transformer invented in 1831 made it possible to reduce the pressure at any point along the line, thus putting the powerful current under perfect control, so that it could be used for all purposes requiring currents of different control.

The more recent discovery of the X-ray and its application to medicine and surgery, and of the Hertzian waves with the development of wireless telegraphy, of the street motor-car, and of the automobile, are too recent to need an account here. While it is true that steam is still our greatest motive-power, electricity is gradually but surely supplanting it. Business men almost invariably prefer it to steam, gas, or water power, owing to its numerous advantages. Its greater cost is in many localities its only drawback. Since 1878 the development of electricity in a commercial way has been marvelous. The inventions of Edison, Westinghouse, and a host of others would fill volumes if one attempted to give an account of the innumerable ways in which they have learned how to apply the principles of electricity to solve the problem of sound, heating, lighting, transportation, surgery, communication, and almost every line of human endeavor.

For many years facts about electricity have been taught in secondary schools, in technical schools, and in universities. In engineering schools it holds of course a position of prime importance. The subject was brought during the past decade or two into some few elementary schools with the movement to enrich the school life, hoping thereby to put life into the "three R's." However, most of the subject-matter as generally taught has been chiefly concerned with experiments in frictional electricity. But frictional electricity plays a very insignificant part in the present use and applications of electricity. Historically it has played a great part in the development of the subject, as it was the point of approach. The pith ball, the friction machine, the Leyden jar, the electrophorus, etc., have held sway often almost to the entire exclusion of the larger field of current electricity. Progress in the electrical field has been so kaleidoscopic that while the pedagogue may have kept pace with a knowledge of this progress he has not kept pace in his educational practice in teaching the subject. Too often he is still manipulating his pith balls, silk and glass, Leyden jars, tinfoil apparatus, etc., evidently oblivious of the fact that the electrical world has long since left them to get dusty on an upper shelf, only taking them down to show the one-time plaything, or as evidence of the progress which they have been instrumental in bringing about. The essential applications of electricity are concerned with current electricity. Probably the fact that most textbooks begin with a treatise on frictional electricity accounts for the method of the teacher who has not yet emancipated himself from slavishness to the dog-eared textbook, which too often is written from a logical standpoint, or in the chronological order of the development of the subject.

Until books intended for use in educational work are psychologized, the teacher to do intelligent work must lay aside poor texts and present his subject so as to make the present experiences and interests of the child the starting-point. It has been well said that "the subject-matter, just as it stands for the scientist, has no direct relationship to the child's present experience."

It is my purpose, in the next article, to sum up some work in electricity done from the above point of view, illustrated by work from the seventh grade.